

(12) UK Patent Application (19) GB (11) 2 270 986 (13) A

(43) Date of A Publication 30.03.1994

(21) Application No 9319178.1

(22) Date of Filing 16.09.1993

(30) Priority Data

(31) 9219591

(32) 16.09.1992

(33) GB

(71) Applicant(s)

Cashmaster International Limited

(Incorporated in the United Kingdom)

12 High Street, ABERDOUR, Fife, KY3 0SW,
United Kingdom

(72) Inventor(s)

Neil James Hunter
Gordon R Vance

(74) Agent and/or Address for Service

Frank B Dehn & Co
Imperial House, 15-19 Kingsway, LONDON,
WC2B 6UZ, United Kingdom

(51) INT CL⁵
G01G 19/42

(52) UK CL (Edition M)

G1W WL
U1S S2131

(56) Documents Cited

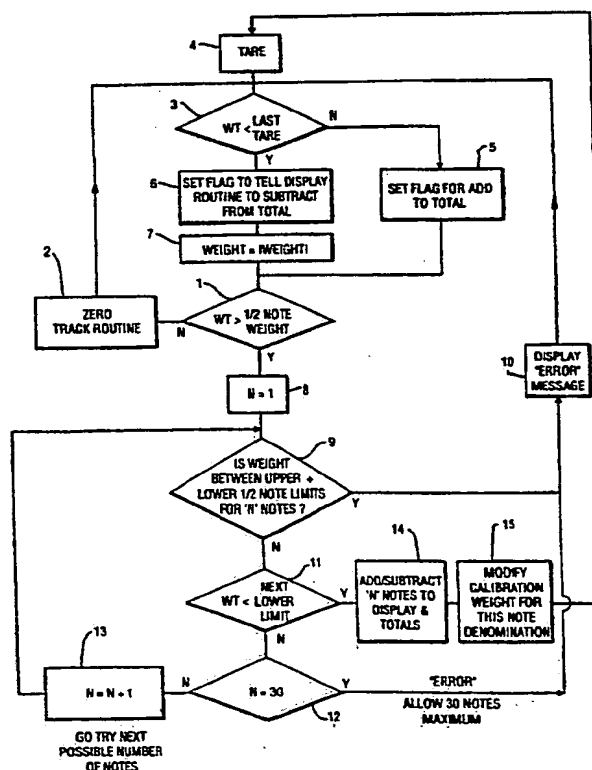
GB 2155190 A GB 1517231 A EP 0091274 A

(58) Field of Search

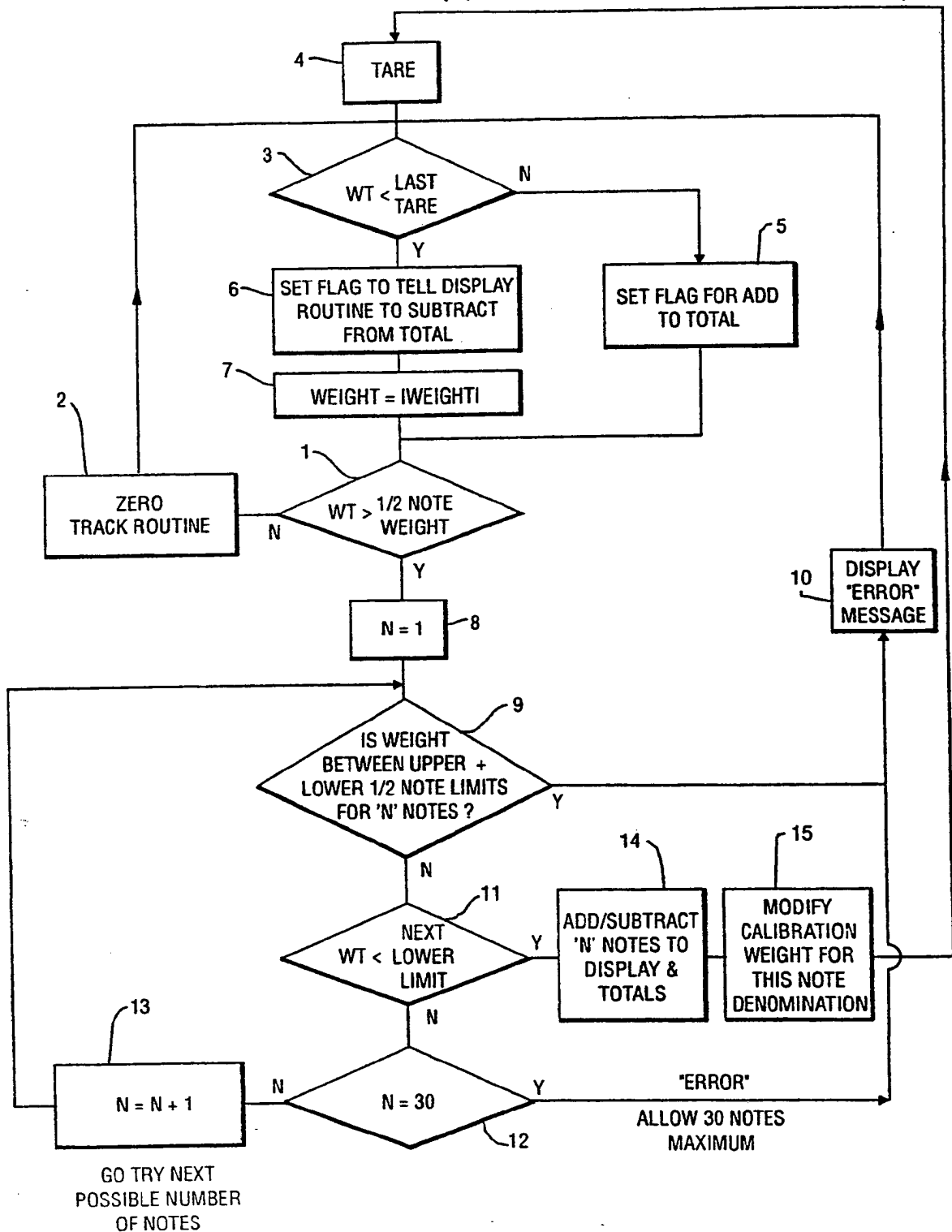
UK CL (Edition L) G1W
INT CL⁵ G01G 19/42
On-line databases: WPI

(54) Method of counting articles by weighing

(57) A method of counting articles by weighing, and particularly currency notes, in which weight data is compared with a table of acceptable and/or unacceptable ranges of values corresponding to acceptable whole numbers of notes. If the value falls outside an acceptable range an error message is given. The table uses weight data directly.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.



Method of Counting Articles

This invention relates to determining the amount of an unknown quantity of articles and establishing whether the accuracy of the result is or is likely to be acceptable. The invention may be applied to determining the number of articles or their monetary value. The invention is particularly relevant to counting currency, and especially bank notes.

In the case of bank notes it is of considerable importance that there be means of taking into account factors such as part notes, adhesive tape and extraneous pieces of paper which will affect the weight readings. A first principle relied upon to date is to consider the extent to which a calculated value for the number of notes (which will in a practical situation hardly ever be an integer) deviates from the nearest integer. If the deviation is too great, then the result may be unreliable. If the deviation is acceptable then that integer is used as the number of notes. However it is also essential to take into account the fact that there will be inevitable minor variations in the weights of standard, acceptable, notes as a result of manufacturing tolerances, age, or absorption of moisture in conditions of high humidity. A second principle used to date is to weigh bank notes in small batches, so that acceptable deviations do not accumulate so as to indicate an unacceptable result, and so that gross errors such as half notes or extraneous matter do not go unnoticed.

A known arrangement employing these two principles is disclosed in GB-A-2076979. This describes a method of counting by weighing in which a large number of notes is

divided into "slices". These slices are stacked on a scale-pan, one at a time. When a first slice has been weighed, that weight is divided by a previously entered average weight to produce a number called an "actual quotient". The nearest whole number ("ideal quotient") to this is then determined. If the difference between the two quotients is less than a predetermined permissible deviation the slice is accepted and a further one may be added. Otherwise, the slice is rejected and the operator checks the slice for damaged or repaired notes.

When a slice is accepted, the difference (deviation) between the actual and ideal quotients is stored in a memory. When a further slice is added, the new total weight is divided by the average weight of one note to give a new actual quotient and a new ideal quotient for the combination of the two slices. In order to avoid the effect of errors accumulating, the previously determined deviation is subtracted from the difference between the new actual quotient and the new ideal quotient to give a new deviation. It is this which is used to assess the accuracy and it is then stored in place of the previous one. The procedure is repeated until the last slice has been added to the stack, at which point the total number of notes can be derived from the final ideal quotient.

This system has various disadvantages. It involves a number of steps. Every time a 'slice' is added to the scale the output value has to be divided by the known mean weight to find the actual quotient. Then the nearest ideal quotient must be found, the difference between the two quotients determined and the previously found deviation subtracted from it. Only after these steps have been performed is the new deviation checked to see whether it is acceptably small. It can be seen that several steps of calculations are needed, thereby increasing the complexity

of the system and increasing the risk of significant rounding errors. In particular, the method includes division of numbers which must be done using a large number of significant figures in order to retain accuracy. The initial dividing step is carried out on a weight value which may range from the weight of a few notes only to the maximum capacity of the scale pan. When this method is implemented in an electronic device, multiple-byte division must be used, making it difficult to use inexpensive 4 bit microprocessors.

It has now been ascertained that by operating in a different manner it is possible to provide for more flexible and advantageous arrangements.

According to an invention disclosed herein there is provided a method of determining the amount of an unknown quantity of articles, and establishing whether the accuracy of the result is or is likely to be acceptable, by steps including recording standard data related to the weight of a quantity of articles whose amount is known, wherein the method comprises the steps of:

- (a) weighing an unknown quantity of articles and providing a parameter whose value is related to the weight of the unknown quantity of articles;
- (b) establishing a series of ranges of acceptable and/or unacceptable values of the said parameter which are associated with particular amounts of articles;
- (c) determining whether the parameter value in respect of the unknown quantity of articles falls within one of said ranges;
- (d) thereby establishing whether the parameter value in

respect of the unknown quantity of articles is acceptable or unacceptable;

(e) also thereby, at least in the event of an acceptable parameter value, recording and/or indicating information representative of the amount of the unknown quantity of articles; and

(f) in the event of an unacceptable parameter value, recording and/or indicating information establishing that an unacceptable value has been identified.

By means of the invention a number of advantageous arrangements can be employed. In particular, it is possible to work directly with weight data rather than calculated quotients; it is possible to look specifically for unacceptable notes; and it is possible to employ different criteria for acceptability in dependence on the number of articles.

Thus, in a preferred arrangement the weight of a known quantity of articles such as banknotes is determined. Typically, the weight of ten notes may be determined and by a simple division step the weight of one standard note stored. Alternatively, the weight of ten can be stored and the factor dealt with at an appropriate time during processing. A maximum permissible number for weighing in a single operation has already been decided. In a typical case this may be thirty notes. It is thus known that there will be thirty ideal weights possible when weighing an unknown quantity, corresponding to one to thirty notes. As regards deviations from the ideal weights, apart from unacceptable weights above the upper limit corresponding to thirty notes there will be a series of ranges lying between the ideal weights which are unacceptable on the basis that

the deviation from the ideal values is excessive. There will also be a corresponding series of ranges around the ideal weights which are acceptable on the basis that the deviation can be tolerated.

If working with acceptable ranges, a comparison is made between the weight data and the series of acceptable ranges. If the data is not within one of the ranges an error message is given. If it is, then the amount corresponding to that range is stored or displayed.

Preferably, however, attention is focused on the unacceptable ranges but it is nevertheless possible to determine the amount. In this preferred case, it is determined in ascending order of ranges whether the weight data falls within a range. If it does, then an error message is given. If it does not, then it is determined whether the data is less than the lower limit of the next unacceptable range. If it is not, then the comparison steps must be repeated for that next range. If it is, however, then it is known that the data is acceptable and the appropriate "ideal" value is that between the two ranges. It would be possible to work in descending order and to look at the upper limits of the ranges.

Thus a table can be established for the possible integral numbers of notes, and for each number an associated range of weight data. However it would be possible to carry out calculation and comparison steps in real time, and to determine whether the weight data satisfies a suitable equation, although this would be more complex.

It will be appreciated that whilst the establishment of predetermined ranges is particularly of use when working directly with weight data, it could also be used in relation to quotients as handled by the prior art system although that is not its prime purpose. A distinction

between a system utilising weight data and one using quotients is that in the latter case there is no need to determine the "ideal" values; they are simply integers and the deviations considered are deviations from these. When using weight data it is necessary to perform certain calculations because the ideal values are not known immediately, but one avoids the problems inherent with carrying out division steps to determine quotients.

The use of ranges can provide a way of providing an asymmetrical range of acceptance around an integer by means of a suitable algorithm, to take into account the greater probability of encountering heavy notes. It is more likely that notes will increase in weight or appear to have increased in weight rather than lose weight for three reasons: (i) it has been found that it is more common for notes to have repair tape applied than for parts to have been torn off; (ii) when humidity increases, notes rapidly absorb moisture and increase in weight, however, when humidity falls, notes dry out much more slowly; and (iii) when parts are roughly placed on scales a positive overshoot is measured. By providing asymmetrical acceptance bands around each ideal quotient it is therefore possible to choose the most statistically appropriate limits of acceptance. However, the calculations necessary cause difficulties if utilising inexpensive four bit microprocessors. By working with ranges of unacceptable values, better results can be given even without using asymmetric ranges.

It is however particularly advantageous to have the scope of the ranges vary in accordance with the quantity of notes being counted. Such an arrangement can provide for reducing ranges of acceptable deviations with increasing quantities. This principle is applicable to the system described above in which ranges are established, and to

systems using the prior art principle.

Thus, in the case of weighing twelve articles and working with quotients, it may be established that an acceptable deviation from twelve is in the range of ± 0.25 . In the case of twenty four, it may be determined that the range should be ± 0.18 . Similarly, there are unacceptable ranges of deviation, which if focusing on the integer twelve would be -0.26 to -0.73 (i.e. unacceptable values between eleven and twelve) and $+0.26$ to $+0.74$ (i.e. unacceptable values between twelve and thirteen); and if focusing on the integer twenty four would be -0.19 to -0.80 , and $+0.19$ to $+0.81$.

Of course, it is not necessary to work with deviations as such, and in the preferred embodiment there are established ranges of unacceptable values for actual weight data, the ranges increasing in accordance with increasing quantities.

Preferred formulae have been established for calculating the ranges of unacceptable values and are as follows:

(1) Lower limit

$$(N-1) + a \left(\left(\frac{1}{\sqrt{N-1}} \right) - \left(\frac{0.6}{(N-1)^{1.3}} \right) \right)$$

(2) Upper limit

$$N - b \left(\left(\frac{1}{\sqrt{N}} \right) - \left(\frac{0.6}{N^{1.3}} \right) \right)$$

where a and b are constants.

Using these equations with $a=b=1$ gives the values set forth in the Table below:-

N	Reject +	Reject -
1	0.60	0.00
2	1.54	1.40
3	2.57	2.46
4	3.60	3.43
5	4.63	4.40
6	5.65	5.37
7	6.67	6.35
8	7.69	7.33
9	8.70	8.31
10	9.71	9.30
11	10.73	10.29
12	11.74	11.27
13	12.74	12.26
14	13.75	13.26
15	14.76	14.25
16	15.77	15.24
17	16.77	16.23
18	17.78	17.23
19	18.78	18.22
20	19.79	19.22
21	20.79	20.21
22	21.80	21.21
23	22.80	22.20
24	23.81	23.20
25	24.81	24.19
26	25.81	25.19
27	26.82	26.19
28	27.82	27.18
29	28.82	28.18
30	29.82	29.18

The values of 'a' and 'b' may be altered to suit the specific requirements of a given situation. Equal values of a and b will give symmetrical bands, as illustrated above. However, as discussed previously, it is more likely that notes will have a higher than a lower expected weight. In order to take account of this, a may be set at 1.1., thereby raising the lower limit of unacceptable values. A corresponding change could be made to the upper limit.

In various modified embodiments of the invention it may be necessary to increase the bands of unacceptability in response to certain events. This is most easily achieved by decreasing a and/or b.

In practice, in accordance with the preferred embodiment, weight values are used in the calculations. Thus, the values for the purposes of comparison will be multiplied by the standard weight data for one note.

The above system has been devised particularly to facilitate accurate and trouble free counting of bank notes, and the ranges have been calculated with particular regard to eliminating troublesome half notes.

It will be noted that for each integer 1 to 30 there is an upper and a lower figure which in fact represents the unacceptable range of values between it and the integer below. When effecting the comparison, the table is approached in ascending order. If a value in an unacceptable range is found, then an error message is given. However, assuming that no such unacceptable reading is located the process continues until the value is found to be below the lower unacceptable limit for the next highest integer. Thus, if the measured weight (w) is 8.2 then the following sequence will occur:-

For $N=7$, the range is 6.35 to 6.67 and w is not in this range. It is not less than 7.33, the lower limit for $N = 8$, and so the comparison continues. For $N = 8$, the

range is 7.33 to 7.69 and w is not in this range. However it is less than 8.31, the lower limit for $N = 9$ and the comparison stops. The value of $N = 8$ is the correct value, with acceptable deviations.

It will be appreciated that in this arrangement one is effectively checking, for a number such as eight, whether the value is within the unacceptable range beneath it (7.33 - 7.69) or the unacceptable range above it (8.31 - 8.70).

In addition to determining the accuracy by the above described method, it is preferred that there also be a stacking system so that a number of slices can be added in such a way that a total is given whilst each slice is considered individually for the purposes of accuracy. In the prior art such a system is achieved by the relatively complex use of a stacking correction, equal to the deviation calculated for a particular bundle. In the prior art system, this deviation from the "nearest ideal quotient" is in any event an inherent part of the accuracy calculation. In an arrangement in accordance with the present inventions, such a deviation is not calculated and effectively one knows only whether there is a deviation within a particular range, but not the magnitude of the deviation.

Accordingly, for use with the methods described above it is necessary to adopt a different way of operating. Thus, successive batches or "slices" of a complete bundle are weighed, each batch being added to the notes already on the weighing pan or the like. However, between each weighing operation the weighing apparatus is tared to zero so that the notes already in place are ignored entirely. Taring can be achieved in several different ways: a force may be applied to the weighing apparatus to counteract the weight of the previous slice; a signal can be subtracted from the output signal from the scale; or the previously

determined weight data can be subtracted from the current weight data. Having tared the apparatus, the calculations are carried out only in respect of the new batch added. Of course, there is kept a cumulative total of the amounts determined but that is all.

Such an arrangement is simple to put into effect. Furthermore, calculations are carried out only on the number of notes in one batch, and not on the entire bundle on the pan. By contrast, in the prior art there may eventually be a few hundred notes on the pan and the total weight of these is calculated, and a division carried out, with the risk of errors. By means of the new method, calculations are carried out only in respect of a maximum of say thirty notes and in any event such division steps are not required.

Thus the use of the error checking system of establishing ranges, and the resetting of the weighing apparatus to zero between batches to be added together, complement each other and provide advantageous results.

Thus, in the most preferred embodiment the method comprises the steps of:-

- (a) Weighing a known quantity of articles on weighing apparatus to determine standard weight data;
- (b) Establishing a table of unacceptable ranges of weight data for numbers of articles up to a predetermined maximum;
- (c) Weighing a first unknown quantity of articles on the apparatus to provide first weight data in respect of the first quantity;
- (d) Comparing the first weight data of the first unknown quantity with a first range in the table;

(e) In the event that the value of the data falls within that range, providing an error message;

(f) In the event that the value of the data does not fall within that range, determining whether it exceeds the lower limit of the next range in the table;

(g) In the event that the value does not exceed the lower limit of the next range, terminating the comparison step and storing article amount information derived from the number associated with the first range;

(h) In the event that the value exceeds the lower limit of the next range, repeating steps (d), (e), (f) and (g) for the next range and subsequent ranges until either an error message is generated in accordance with step (e), or article amount information is stored in accordance with step (g), or it is determined that the weight data exceeds the predetermined maximum and an error message is provided;

(i) Effecting a tare operation in respect of the weight of the first unknown quantity of articles;

(j) Adding a second unknown quantity of articles to the first unknown quantity;

(k) Weighing the combined quantity of articles but as a result of the tare operation providing second weight data whose value is only determined by the weight of the second unknown quantity;

(l) Repeating steps (d) to (h) but in respect of the second weight data, and if article amount information is to be stored in accordance with step (g) then adding it to the

article amount information already stored; and

(m) If necessary repeating steps (i) to (l) in respect of further unknown quantities of articles; whereby there is stored article amount information in respect of the cumulative unknown quantity of articles, whilst weight data in respect of each separate quantity has been checked against unacceptable possible values.

There are various other steps which may be incorporated in embodiments of the invention, depending on the circumstances in which the method is used. Thus, the error limits in the table may be adjusted in a variety of ways to cope with different patterns of variation in the quality of notes being counted. By maintaining some simple statistical data on a small number of recent "slices" a number of minor adjustments to error limits tables and average weight factors can be made with a high degree of confidence.

The values maintained/calculated should include:-

- separate records of the mean note weight calculated from each of the last few slices weighed
- an estimate of variance of these weights calculated as follows:

$$\text{Variance} = \frac{1}{n-1} \left\{ \sum x^2 - \frac{(\sum x)^2}{n} \right\}$$

where n = no. of slices used in the calculation

x = average note weight calculated for a slice

$$\text{standard deviation of means} = \sqrt{\left(\frac{\text{variance}}{n} \right)}$$

Some example error limit adjustment strategies would include:-

- a) if the variance of recent slices of notes weighed is high and/or the error limit strategy presently being used indicates a high number of unacceptable weighings then reduce the maximum number of notes which may be weighed in one "slice"
- b) if the variance of recent slices of notes is high then reduce the limit tolerance applied for high numbers of notes in one slice (for example more than 15 notes per slice)
- c) if historical weight data suggests a high number of "repaired" notes are being counted then bias the limits table in favour of accepting slightly "heavy" notes
- d) if the operator's style of use is to "throw" notes on to the unit causing weight "overshoot", bias the limits table in favour of "heavy" notes
- e) when the machine is not counting notes an assessment of background noise from air currents & vibration can be made. Use this to tighten the limits and/or reduce the maximum number of notes allowed per slice eventually to the

point where operation is inhibited if vibration/noise are too severe for reliable counting

f) when counting the first few slices of any denomination of note on a new or recently recalibrated machine tighten the error limits and/or reduce the maximum number of notes allowed per slice until such time as the machine has "learned"

g) increase the margins of acceptance for 5-15 notes (the most likely number applied in one "slice") if the last few slices weighed have all fallen close to an unacceptable limit value.

One way of further reducing the chance of errors due to seasonal variations in the average weight of an article is to redetermine the average weight shortly before weighing the first quantity of articles. The method may be modified such that this must be done. For example, apparatus on which the invention is implemented may be designed not to permit weighing an unknown quantity of articles unless a known number has previously been weighed. Such a function could depend upon the time which has expired since the previous use of the apparatus, so that if this period were more than a predetermined maximum, a re-calibration would be forced.

A further refinement which may be appropriate in certain circumstances is to set a maximum permissible number of errors per counting operation, or per a certain number of steps. In the event that this number is exceeded, the whole operation would be considered void, thereby forcing a check of the entire batch of articles.

Another modification is that in the event that significant numbers of slices are weighed which are near,

but within, the limits of the acceptable range, (or just outside an unacceptable range) it is possible that the ranges may be made more critical for further measurements. This is most likely to be appropriate when there are fluctuations from positive to negative errors in subsequent slices. Similar, and roughly consistent error readings are best dealt with by a "tracking" system.

Tracking systems are well known in this field. In such a system, the data related to the weight of a known quantity of articles (for example the weight itself) is adjusted in the light of measurements performed on unknown quantities of articles. In other words, the initial average weight (for example) is used as a starting point from which unknown quantities of articles are determined in the manner discussed previously. Assuming that the articles are within the acceptable (or outside the unacceptable) ranges, after the number of articles has been determined, their actual average weight is calculated and this is compared to the initial average weight. The initial value may then be adjusted towards the measured value. This adjustment is restricted to within a certain amount (eg. $\pm 5\%$) to avoid the average weight drifting too far from the initial value. One way in which tracking may be implemented is to adjust the mean weight according to an equation such as the following:

$$w' = w + \frac{1}{c} (w - \bar{w}) m$$

where:

w = previous stored average weight

w' = new stored average weight

\bar{w} = mean weight of all items counted
 m = number of items counted
 c = constant

typically 'c' is a value which is chosen so that the average corresponds to a large number of notes, such as the previous 200 or 1000.

Techniques for automated "learning", where the machine calculates a long term average weight for all notes of each denomination and uses this continually adjusted value for on-going calculation and error limit testing, operate well for slow changes in average note weight caused by wear, seasonal humidity changes etc. but does not address short term fluctuations caused by batches of notes from different sources being weighed consecutively.

For example in a banking situation the same machine may be used to count new notes from a vault, and then immediately thereafter be used to count old or damaged notes from a customer transaction. This can lead to frequent error indications and hence slow throughput or, at worst, to miscounts.

A method of quickly updating the average note weight on a batch-by-batch basis whilst still maintaining the traditional long term average weight is required to counter these types of "real world" problems.

An alternative strategy proposed is as follows:

- a) maintain average note weight data obtained from the last few slices of each denomination (for example 5 slices)
- b) continually calculate a new mean note weight and an estimate of population variance from these slices

c) make an assumption that the mean weights of these slices follow a "t" distribution

d) calculate a "t" value as follows:

$$t = \frac{(\text{mean of recent slices}) - (\text{current mean weight})}{\text{standard deviation of recent means}}$$

- e) if the "t" value exceeds a predetermined "confidence" value (for example, 3.75 for 99% confidence after 5 slices) then assume that the mean weight of ALL notes in the batch presently being counted has changed and adopt the mean weight calculated from the last few slices as a temporary average note weight for future limit checks calculations on this batch of notes only
- f) when all notes are removed from the unit, return to using the average note weight calculated in the normal manner where all notes applied to the unit contribute equally to the calculation.

It is also possible for the maximum slice size to be varied, for example in response to a high number of unacceptable slices, or even when there have been no unacceptable slices, but there is a large fluctuation in note weights. By reducing the slice size in these circumstances, the chance of a mis-count is reduced. Reduction in maximum slice size may also be appropriate when there is a likelihood that the standard weight related data may be different from the corresponding actual values, for example when a period of time has elapsed since the standard data was determined. This may be particularly appropriate when a tracking system is used, so that small

slice sizes are used until the standard data has been suitably modified.

In the most sophisticated embodiments of the invention, accuracy may be increased further by analysis of rejected slices. For example, in the case of a money counting operation, if the weight (or the weight-related data) is very close to that of a half note, or a note of a different denomination from those being counted, an indication of this could be made in order to assist detection of the "rogue" note. If such a system were implemented on a weighing machine with a scale pan, the user would remove notes until the "rogue" note is discovered. At the same time the range of acceptable notes could be decreased or the range of unacceptable notes increased. In order to make the determination of the presence of different denomination notes, further standard data would be required. However, it is likely that a device implementing the methods of the inventions would be designed to cope with a variety of denominations of notes (or a variety of standard sizes of other articles), and therefore such information may already be stored in the device.

The operator can be advised of attempts to count notes of a different denomination from that selected on the unit. This can often happen when new and old issue notes of the same face value are both in circulation.

In a preferred arrangement, during weighing of the first few slices of notes only, if a small number of notes (say 10 or less) has just been weighed and falls outside the acceptance limits for the operator's selected note denomination, the unit will automatically scan through the limits tables for all other possible alternative note denominations checking for a close match to the weight of this slice. If a match is found the operator will be given

a visual and/or audible indication that the denomination selected may not be correct. As an option the unit may automatically select an alternative denomination.

An embodiment of the invention will now be described, by way of example only, with reference to Figure 1 which is a flow chart.

This embodiment is adapted for counting bank notes and is particularly suitable for implementation in an electronic device having a scale pan, an electronic data processing system and a digital display. Initial values of average weights may be entered before delivery of the device to the customer, or may be entered by a user by placing a known number of notes on the scale pane before counting a batch of notes. Ranges of unacceptable values such as those in the above table are stored in memory. By multiplying these values by the average weights of the notes which are to be counted, actual unacceptable weights are determined.

Starting at decision box 1, which checks whether a weight greater than half a note is present, until a first slice is placed on the pan the result will be no (N). Given this outcome, a zero track routine 2 is enabled which is analogous to the tracking routine described earlier. The purpose of this is to ensure that there is a zero weight reading when no notes are present. Then at decision box 3 a check is made as to whether the weight is less than that after the previous tare. This tare will have occurred (at box 4) with no notes on the scale so the weight at both times is zero and the decision is therefore no (N). (If the result had been yes (Y) as could occur during an operation if notes were removed, boxes 6 and 7 enable the display to show a reduction in the number of notes on the scale).

Next, box 5 sets a flag (which determines whether

notes are being added or removed to "add" and then the decision of box 1 is repeated. The above loop will be repeated until notes are added to the scale pan, at which point there will be a yes (Y) result from box 1.

After such a result a control variable N is set to 1 (box 8). This starts the process by which the weight is compared to the various unacceptable values. The "weight" is the output from the electronic scales which may be a voltage from a load cell, converted to digital form. The stored known average weights will be in the same form so that all weights are directly comparable. As discussed above, the ranges of unacceptable values are obtained by multiplying the unacceptable range values given in the table by the known weight of one note. In box 9 a check is made to determine whether the weight is within the unacceptable range for N notes (at this stage 1 note). If it is, then the yes (Y) output results in an "Error" display (box 10). After a no (N) output, box 11 checks whether the weight is less than the lower limit of the next range of unacceptable values. In the event of a no (N) output box 12 then checks that the maximum permissible number of notes (30) has been reached. If so box 10 generates an error message. At this stage $N=1$, therefore the output is no (N). Box 13 then increases N to 2 and there is a loop back to box 9. This sequence is repeated until either N reaches 30 or the weight falls within an unacceptable range (both of which give error outputs), or a yes (Y) output is produced at box 11.

This latter result occurs when there is an allowable weight of notes. When this occurs, the number of notes in the slice has been found to be 'N'. This number is added to the stored total number of notes (initially zero) and displayed. Then the tracking routine 15 is implemented to modify the known (calibration) weight for the notes being

counted. After this, the output from the scale pan is tared (box 4) in order to give a zero weight reading without removing the first slice from the pan. This is done by subtracting the digital weight data from a digital output derived from the load cell. Box 3 checks that notes have not been removed and the first loop described above is repeated until a second slice is added, after which the second loop is repeated to determine the number of notes in the second slice, or produce an error warning.

In the event of an error display, notes are removed from the scale pan until a torn or repaired note is found. When this occurs, the reduction in weight will cause a yes (Y) output from box 3 and the add/subtract flag will be set to "subtract". Box 7 ensures that a positive value is displayed.

The above procedure is repeated until all the slices of notes have been added to the scale pan. When the number of notes in the final slice has been determined, the displayed total will be the number of notes in the batch.

Claims

1. A method of determining the amount of an unknown quantity of articles, and establishing whether the accuracy of the result is or is likely to be acceptable, by steps including recording standard data related to the weight of a quantity of articles whose amount is known, wherein the method comprises the steps of:

(a) weighing an unknown quantity of articles and providing a parameter whose value is related to the weight of the unknown quantity of articles;

(b) establishing a series of ranges of acceptable and/or unacceptable values of the said parameter which are associated with particular amounts of articles;

(c) determining whether the parameter value in respect of the unknown quantity of articles falls within one of said ranges;

(d) thereby establishing whether the parameter value in respect of the unknown quantity of articles is acceptable or unacceptable;

(e) also thereby, at least in the event of an acceptable parameter value, recording and/or indicating information representative of the amount of the unknown quantity of articles; and

(f) in the event of an unacceptable parameter value, recording and/or indicating information establishing that an unacceptable value has been identified.

2. A method as claimed in claim 1, wherein the series of ranges of values is provided in a table.
3. A method as claimed in claim 1 or 2, wherein the values consist of weight data.
4. A method as claimed in claim 1 or 2, wherein the values consist of quotients obtained by dividing weight data by a unit weight.
5. A method as claimed in any preceding claim, wherein at least some ranges are asymmetrical about an ideal value.
6. A method as claimed in any preceding claim, wherein the extent of the ranges varies in dependence on the quantity of articles.
7. A method as claimed in any preceding claim, wherein there is a limit to the quantity of articles that can be weighed in one operation.
8. A method as claimed in claim 7, wherein the quantity limit is varied in dependence on the variance of recent quantities of articles weighed.
9. A method as claimed in any preceding claim, wherein the extent of the ranges is adjusted during operation to take into account statistical data in respect of recently weighed quantities of articles.
10. A method as claimed in any preceding claim, wherein average article weight data is varied to take into account statistical data in respect of recently weighed quantities of articles.

11. A method as claimed in any preceding claim, wherein if a quantity of articles gives an unacceptable value, a check is carried out to determine whether an acceptable value would be given if using a different series of ranges corresponding to a different article to that selected.

12. A method as claimed in any preceding claim, used for counting currency notes.

13. A method for determining the amount of an unknown quantity of articles substantially as hereinbefore described.

14. Apparatus for determining the amount of an unknown quantity of articles, adapted to operate in accordance with a method as claimed in any preceding claim.

Search Examiner
T S SUTHERLAND

Date of completion of Search
22 November 1993

(ii) Int Cl (Ed.5) G01G 19/42

Documents considered relevant following a search in respect of Claims :-
1-12

(ii) ONLINE DATABASES: WPI

X:	Document indicating lack of novelty or of inventive step.	P:	Document published on or after the declared priority date but before the filing date of the present application.
Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☒ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)